The Maintenance of the Blocking over the Ural Mountains during the Second Meiyu Period in the Summer of 1998

Li Shuanglin (李双林), Ji Liren (纪立人) and Lin Wantao (林万涛)
LASG, Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing 100029

Ni Yunqi (倪允琪)
Chinese Academy of Meteorological Sciences, Beijing 100081

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ABSTRACT

The 1998 summer-time floods at the Yangtze River basin of China, the severest in last 50 years or so, directly resulted from the abnormal extension of Meiyu (rainy season), which was related to a weak East Asian summer monsoon and persistent anomalies of extratropical circulation. The long persistence of blocking over the Ural Mountains is a conspicuous feature. The physical processes responsible for the prolonged maintenance of this key system are investigated in terms of internal forcing (transient eddy upon basic flow) and external forcing (tropical heating forcing) via diagnosis and numerical experiments in the paper.

Using the adjoint method, the location and structure of optimal perturbations favorable for the development and maintenance of Ural blocking are identified, which shows an apparent coincidence with the observed storm track at the eastern Atlantic to Europe sector. The diagnosis of E-vector and the response of baroclinic stationary wave to transient forcing both suggest further that the enhanced transient eddy activity favors the occurrence and maintenance of positive anomalies.

The upper-level jet and heat sources (sinks) during that period are calculated, and the results indicate that the anomaly of upper jet and tropical heating is evident. The ensemble forecasting experiments by a GCM, IAP T42L9 show that the anomalous heating over the tropics, especially over the central-western Pacific and Atlantic, favors the formation of positive anomalies of height at the Ural region. Finally, a self-sustain mechanism of positive anomalies through two-way interaction between planetary stationary wave and transient eddy under the stimulation of anomalous tropical heating is proposed.

Key words: 1998 floods in China, Blocking high over the Ural Mountains, Tropical abnormal heating, Transient eddy, Two-way interaction

1. Introduction

The 1998 floods at the Yangtze River basin in China are the second severest in the 20th century next to 1954. Its direct and primary cause is the anomalous extension of Meiyu (rainy season) (Tao et al., 1998; Huang et al., 1998), which, in turn, is closely associated with anomalous circulation. There existed three anomalous aspects of atmospheric circulation over East Asia (Yan, 1998): (1) ITCZ is weaker than normal, and thus there are less tropical storms over the tropical western Pacific; (2) blocking patterns emerge frequently at middle and high latitudes, especially over the Ural Mountains and the Okhotsk Sea; (3) the subtropical high

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over the western Pacific (hereafter, SHWP) is weaker and situated in a position south of the normal. So the anomalous lasting of the blocking high over the Ural Mountains is an important aspect of circulation pattern, as was also found by other researchers (Bi, 1998; Yang, 1998). There have been less studies on summer—time Ural blocking so far in comparison with those over Northeast Asia, especially over the Okhotsk Sea, which is associated with abnormal Meiyu more closely. But the twin blocking pattern with one over the Ural Mountains and the other over the northeastern Asia is an important pattern resulting in Meiyu, especially during the middle and later phases (Zhu et al., 1982). The floods at the Yangtze River basin are usually related to the prolonged Meiyu period, therefore it is essential to study the formation and maintenance of Ural blocking, in particular, those of prolonged persistence.

There are many theories on the formation and maintenance of blocking, among which the forcing from synoptic—scale transient eddy (internal forcing) upstream and that of heating source (external forcing) are widely cited (Shutts, 1983; Shukla and Wallace, 1983). Liu and Wu (1996) studied the maintenance of the blockings over the North Pacific, the North Atlantic Ocean and Alaska individually, and found that the relative importance of transient eddy is different. Nakamura et al. (1997) compared the roles of transient eddy and low—frequency wave in the blockings over Europe and the Atlantic individually, and pointed out that the quasi—stationary wave train plays a more important role than transient eddy in the blocking over Europe, while it is contrary over the Pacific. The low—frequency wave is related to external forcing, especially the tropical heat sources. Lu and Huang (1996) conducted numerical experiments to study the impact of the SSTAs over the tropical western Pacific upon the blockings over the northeastern Asia, and pointed out that the negative SSTAs is in favour of the maintenance of the blocking. Tropical heating can also influence blocking through the Hadley circulation, upper jet and transient eddy indirectly.

The strongest ENSO event in the last century occurred in 1997 / 98, which reached its peak in December 1997 and began to retreat from May 1998. There was a band of cold water along the equator near the dateline in June. It is under the background of ENSO event that the floods occurred. Some studies (e.g. Tao et al., 1998; Huang et al., 1998; Yan, 1998, etc.) suggest that the abnormal precipitation in summer over the Yangtze River basin does not response to ENSO as directly as that over the areas such as South America, North African and Indian monsoon areas, but is related to the evolution of events. And the floods are likely in the following, rather than the current, year of an ENSO event. However the physical mechanism underlying remains unclear.

The long maintenance of the blocking over the Ural Mountains is studied in terms of two aspects, namely internal and external forcing, especially tropical heating. This paper is written in five sections. In Section 2 the persistent anomaly of circulation over the Ural Mountains is defined, and its connection with abnormal Meiyu is investigated. In Section 3 the long maintenance of the blocking over the Ural Mountains is diagnosed, and the roles of transient eddy and tropical anomalous heating are explored. Section 4 is the numerical experiments, in which the contribution to the blocking from the synoptic—scale transient eddy is estimated by a baroclinic linear stationary wave model (Ting and Held, 1990), and that from abnormal heating over different tropical areas is studied through ensemble experiment of a global GCM, IAP T42L9. The last section contains a summary and discussion.

The data set used here includes NCAR / NCEP reanalysis from 1980 to 1997 for grids of 2.5 by 2.5 longitude—latitude degrees. And for the 1998 data, NCEP analysis was used instead